FLORISTIC INVENTORY OF THE TROPICS: WHERE DO WE STAND?[1]

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In a review of the vast topic of the inventory situation in the entire tropics I can only skim over the surface. I have aimed to pinpoint a few of the significant contributions (many other important ones are omitted) and to draw attention to some of the areas in need of further work. These include both geographical areas that are poorly collected and disciplines which are still neglected in our basic survey of the fascinating vegetation of the tropics. There is still a great deal to be done and time is running out as the natural vegetation is being destroyed. Brazier et al. (1976) said: "More efficient use of the natural tropical forest could be achieved if sufficient information on the extent, composition and structure of the resources were available."

The data which we collect from botanical inventory are not only useful for the study of floristics and evolution, but are also of vital importance for both conservation and utilization of the tropical vegetation.

OF WHAT ARE WE MAKING AN INVENTORY?

Table 1 gives a summary of the estimated number of species in the different major plant groups, compiled from the best available sources. The tropical flora consists of some 155,000 species of flowering plants, 11,000 ferns and fern allies, 16,000 bryophytes, and at least 90,000 fungi. The tropical flora is by far the richest in species diversity, yet it is also the most poorly collected. This diversity is being reduced before we have made an adequate basic inventory let alone conducted modern biosystematic and population biology studies in the area. Even to understand the origin and dynamics of our temperate flora, it is essential to have adequate knowledge of the tropical flora from which the temperate flora was derived.

Tropical Africa has the smallest number of angiosperm species, 30,000, including various islands and the 10,000 species of Madagascar (Koechlin, 1972). Tropical Asia, Australia and the Pacific have at least 35,000 species, and tropical America has about 90,000 species or 37.5% of the worldwide total. Unfortunately, the state of knowledge of these floras is also inversely proportional to the species diversity, with the American tropics much more poorly known than the African and Asian tropics.

In any discussion of inventory of the tropical flora it is important to consider habitat diversity and species diversity. We tend to ignore the habitat diversity of the tropics which contributes to its species richness, and to think of it as one

[1] I am grateful to the many people who have helped to provide information about the areas of their specialty especially to Mr. F. N. Hepper, Drs. F. R. Fosberg, M. Jacobs, Alain Liogier, W. Meijer and A. Gentry. I thank Mr. W. C. Steward for much bibliographic assistance, Mrs. F. Maroncelli who typed the manuscript, and Drs. Howard Irwin and Scott Mori for reading the manuscript critically.

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TABLE 1. Estimated species numbers of major plant groups in the world and in the tropics. Data compiled from many sources such as Ainsworth (1961: 405–407), Jacobs (1974, 1977), and Raven (1976a).

Taxa	Worldwide	Tropical	Tropical Africa	Tropical Asia	Tropical America
Flowering Plants	240,000	155,000	30,000	35,000	90,000
Fungi	120,000[a]	90,000	20,000	20,000	50,000
Ferns	12,000	11,000	1,000	6,000	5,000
Mosses	12,000	9,000	—	—	—
Hepatics	11,000	7,000	—	—	—
Algae	17,000	—	—	—	—
Lichens	16,500	—	—	—	2,500

[a] Other estimates for fungi are as high as 250,000 species, e.g., Martin (1951), Jones (1951), and Rogerson (pers. comm.).

large uniform rain forest. In fact, the tropics contain many arid regions with deserts or scrubland, such as the caatingas of northeastern Brazil, a large temperate element in the flora of high mountains, and a unique alpine flora such as that of the páramos in South America and the Afro-alpine region described by Hedberg (1964), besides many different types of forest and savanna. The habitat types of Malesia were summed up by Jacobs (1974), those of South America by Hueck (1966), and those of Africa by White (in press) in a book to accompany the second edition of the UNESCO vegetation map of Africa. There is not time here to summarize the fascinating diversity of habitat in the tropics, but it is important to collect from and to plan conservation of this habitat diversity. Until now collecting has given rather uneven coverage to the different habitats. The location of different habitats has been overlooked frequently in biogeographic analyses of the neotropical vegetation, although the inventory of habitat distribution is vital to biogeographic studies.

WHAT IS LEFT TO INVENTORY?

The tragedy of the biological inventory of the tropics is that destruction of the vegetation is proceeding more rapidly than the inventory. The tropical flora occurs mostly within the territory of developing countries where technological advance is urgent. Such advance traditionally includes the destruction of large areas of natural vegetation for replacement by farms, timber concessions, developing towns, etc. In addition there is population pressure in many tropical countries where the annual net population increase is often over 3% (see, for example, The Environmental Fund, 1976).

Many authors have drawn attention to the destruction of the natural vegetation in the tropics, for example, Gómez-Pompa et al. (1972), Richards (1973), Janzen (1974), Holdridge (1976), Myers (1976), Raven (1976b), Gentry (1978b), and many of the authors in Prance & Elias (1977). It is not the purpose of this paper to review in detail the destruction of the tropical vegetation, but as the tropical areas are vital for the understanding of the biology and evolution of all plants, it is important to draw attention to the urgent need to accelerate all biological inventory and conservation work in the tropics. According to recent estimates 49.2 acres of tropical rain forest are being removed each minute or a total of 11,000,000 hectares a year (Lucas, 1977; Sommer, 1976). Inventory work daily becomes a more important task to perform, as destruction of natural habitats encroaches. Since there is not a separate treatment of conservation in this symposium, I feel that it must logically be stressed as part of the inventory. It is not possible or profitable to list examples of tropical destruction from each area discussed below, but I draw attention to this race between inventory and destruction in the tropics and hope that we can also focus our efforts more towards conservation. None of the other subjects treated at this symposium can be completed without the conservation of large areas, and without a comprehensive basic inventory.

The Regional Status of Inventory

AFRICA

Progress on the status of systematic work in tropical Africa is readily accessible through the publications and symposia of the "Association pour l'étude taxonomique de la flore de l'Afrique Tropicale" (AETFAT). This organization publishes an annual index which includes a bibliography and lists of new taxa and nomenclatural changes for all tropical African plants. Progress reports on collections, the regional floras, mapping, etc., are given in the proceedings of their symposia which take place every fourth year (see, for example, Hedberg & Hedberg, 1968; Kubitzki, 1971). AETFAT plays a similar role for Africa as *Flora Malesiana* does for Asia in making available much information and bibliographic data invaluable for research in the area. A review of the current status of collecting in tropical Africa was given by Hepper (in press).

Léonard (1975) prepared, for AETFAT, a map of the extent of floristic exploration in Africa south of the Sahara up to 1963. This map divided the region into 3 categories: poorly known, moderately known and well-known areas. Hepper (in press) gave up-to-date information of changes to this map and a revised edition will be presented at the 1978 AETFAT Congress.

The *Flora of Tropical Africa* (Oliver, 1868–1937) is the only attempt at a general flora of the region. This has been largely replaced by the modern regional floras, especially the *Flora of West Tropical Africa* (recently revised), *Flora of Tropical East Africa*, and *Flora Zambesiaca*. Current African floras are summarized in Table 2.

Statistics for the description of new taxa in Africa from 1953–1965 were summarized by Léonard (1968) and showed a gradual decline from 1,177 new names (577 new species) in 1953 to 723 new names (287 new species) in 1965. The rate of description of new species continued at approximately the same rate in 1971–1975 and is shown in Fig. 1. The fact that 270 new species were described in 1975 shows that the basic species inventory of the African flora has not yet ended. Figure 1 also shows the amount of synonymy proposed in the years 1971–1975 (data from the AETFAT indices). It shows that there is apparently a gradual drop in the net gain in species because of increasing synonymy, 218 net gain in 1971 as compared with 119 in 1975. Nevertheless, the total

TABLE 2. Principal regional floras of tropical Africa.

Publication		Editor or Author
Flora of West Tropical Africa	ed. 1	Hutchinson & Dalziel (1927–1936)
	ed. 2 revised by	Keay et al. (1954–1972)
Flora of Tropical East Africa		Turrill & Milne-Redhead (1952–)
Flora Zambesiaca		Exell & Wild (1960–)
Flora of Egypt		Laurent-Täckholm (1941–)
Flore du Sénégal		Berhaut (1954, 1967)
Flore du Gabon		Aubréville (1961–)
Flore du Cameroun		Aubréville (1963–)
Flore du Congo, du Rwanda et du Burundi		Robyns (1948–)
Syllabus de la Flore du Rwanda		Troupin (1971)
Conspectus Florae Angolensis		Carrisso (1937–)
Prodromus einer Flora von Südwestafrika		Merxmüller (1966–)
Flora of Southern Africa		Codd et al. (1963–)
Flore de Madagascar et des Comores		Humbert (1936–)

number of new descriptions in Africa south of the Sahara for the 21 year period, 1953–1973, are impressive: 391 new genera, 7,478 new species, and 2,538 infraspecific taxa. That is a new genus every 3 weeks and a new species for every day of the 21 years (data from Hepper, in press). A flora in this active state of description that is still adding 1,000 new species over a five-year period is obviously also in need of further collecting. Many of the reports on the progress of various African floras given in Kubitzki (1971) include emphasis on the need for further collecting, for example, Boulos (1971) for Libya, Aké Assi (1971) for the Ivory Coast, Le Thomas (1971) for Gabon, etc.

Distribution maps of African taxa such as those published by Bamps (1969) in the very useful series "Distributiones Plantarum Africanarum" (see Fig. 2), show that the African flora is really well explored in comparison with the Neotropics. For this reason more analytical phytogeographic papers have come from taxonomists working on the African flora. The better known plant distributions have enabled much better phytogeographic analysis of the flora, see, for example, White (1962, 1965, 1971), the introductory chapters in Chapman & White (1970).

Hepper (in press) summarized the collecting situation in Africa as still having large gaps. He said that general collections are now required only from lesser known regions, and he stressed the need for specialist collections and for resident botanists to carry out long-term investigations. He pointed out some particular gaps in collecting such as the tendency to collect mountain tops and ignore the forested slopes. For further information about Africa the reader is referred to Hepper's paper.

The native African flora has been disappearing rapidly under human popu-

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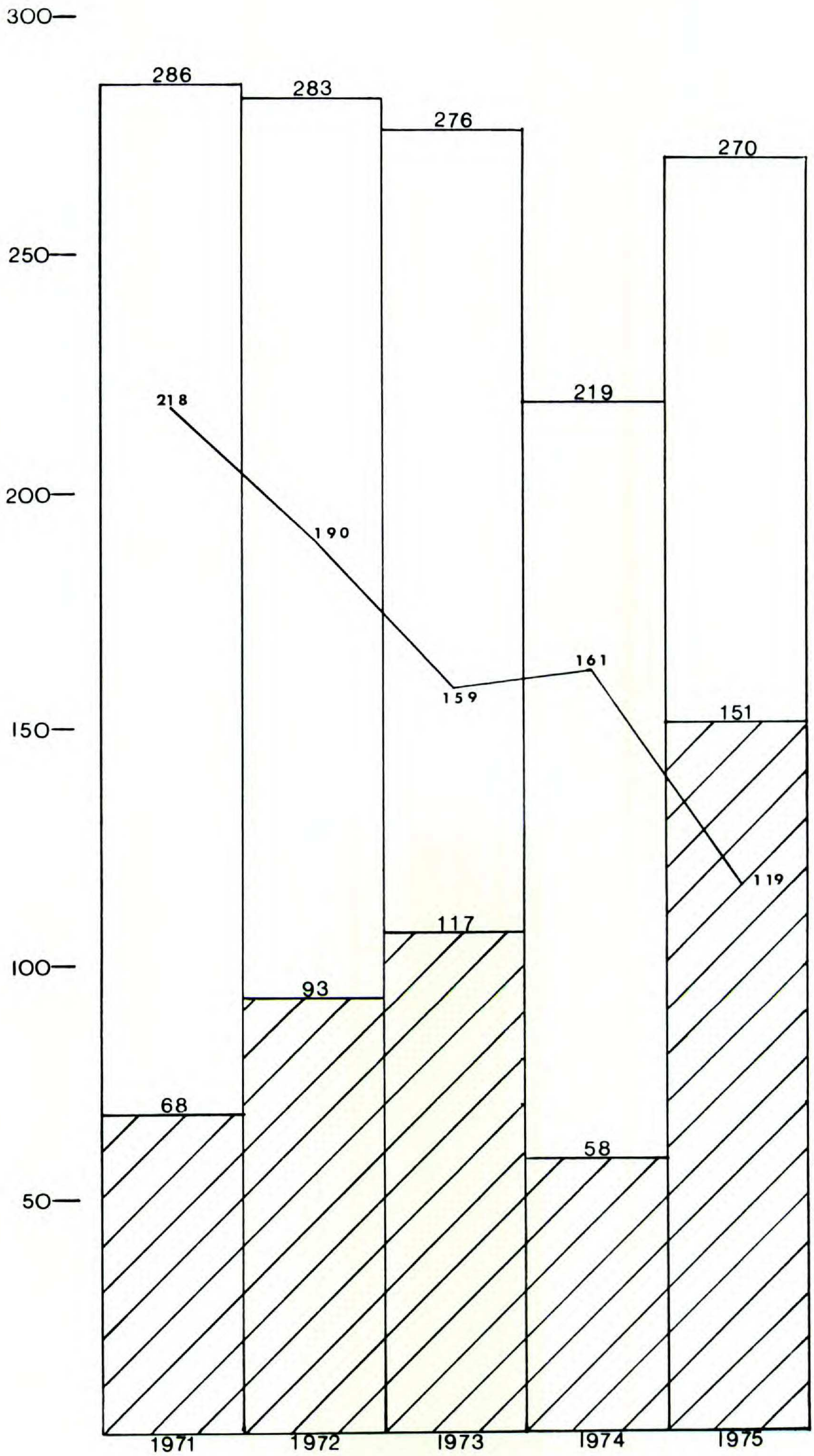
FIGURE 1. The description of new species in tropical Africa: data from the AETFAT Index, 1971–1975. The open area represents the total number of new species described, the cross hatched area superimposes the number of species names reduced to synonymy. The graph in the center represents the net gain in species each year.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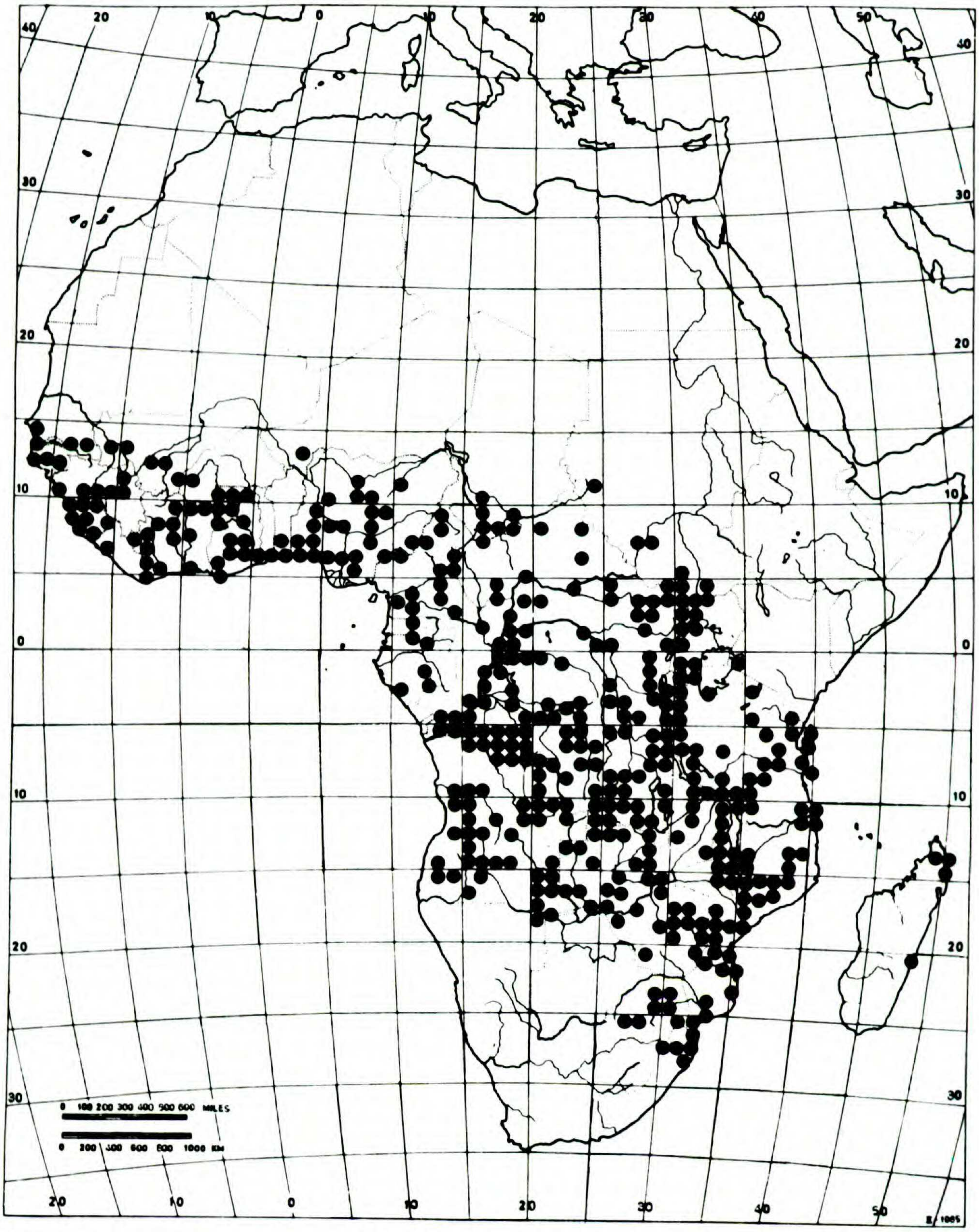

Chrysobalanaceae **327. - *Parinari* Aubl. (1775)** **F. White**

Synthesis tabularum 328-334

FIGURE 2. Distribution of the genus *Parinari* Aubl. (Chrysobalanaceae) in Africa: From White (1976) Distributiones Plantarum Africanum 10: 281–334. The dots represent presence in a degree square.

lation pressure for longer than that of Malesia or the neotropics. Shantz (1948) discussed the shrinkage of the tropical forests of Africa and Shantz & Turner's (1958) photographic account of the destruction of the vegetation of Africa is a frightening report for any biologist. Hepper (in press) also stressed the urgency for collecting the poorly known areas because of the rate at which the natural vegetation is disappearing.

In Madagascar, where the largest contributions have been made by H. Perrier de la Bathie and H. Humbert, the original species-rich forests have been almost totally disturbed (Gentry, pers. comm.), and the race to collect this exciting flora before it is obliterated is lost. Koechlin (1972) summarized the situation in Madagascar: "Many problems still have to be solved in the field: although the exploration of the flora is well advanced, much remains to be done in the areas of plant biology and phytosociology."

TROPICAL ASIA

The Asian tropics are probably not as well collected as Africa, but are much better known than the neotropics. Much information about tropical Asian botany has been compiled and published in *Flora Malesiana* and its extremely useful *Bulletin*, largely through the initial efforts of Professor C. G. J. van Steenis. The *Flora Malesiana* project covers Indonesia, Malaysia, Brunei, the Philippines, Singapore, eastern New Guinea, and the Solomon Islands. An excellent summary of the botanical status of the region has been given by Jacobs (1974). The situation has changed little since that report. The history of collecting in Malesia is given by Mrs. van Steenis-Kruseman (1950) in a "Cyclopaedia of Collectors" published in volume 1 of *Flora Malesiana* and updated from time to time in the *Flora Malesiana* and in the *Bulletin*, for example, van Steenis-Kruseman (1958, 1974, 1977). It is not, therefore, necessary to repeat the data given in these sources but rather to indicate some of the gaps in collecting as given below.

Dr. Jacobs (pers. comm.) lists the following places in Malesia as undercollected and in need of further basic inventory: The Andaman Islands, Southern Sumatra, Central Borneo, Celebes, Kabaena, Ceram (expedition planned), West New Guinea (especially Meerilakte and the Star Mountains in West Irian), the Kikari area in the south of Papua, the Philippines (especially the Sierra Madre on the east coast of Luzon), and the Cape York peninsula of Australia which has in recent times yielded several genera that were known only from Malesia. The northwest Australian coast is still poorly known. Perhaps Celebes is the least collected area and is now less known than New Guinea, especially the eastern and southeastern area of the island. Celebes also illustrates the race against development, since the International Nickel Company in cooperation with Bechtel has a billion dollar nickel mining concern in Celebes. Table 3 from *Flora Malesiana* reproduces their synthesis of the collecting situation in the larger units of Malesia. It points to the need for further collections from Sumatra and Celebes.

Jacobs (1977) has summarized the progress in the publication of *Flora Malesiana*. By the end of 1976, 116 families, 453 genera, and 3,288 species of angiosperms had been monographed out of an estimated total of 25,000 species. The fact that only 13.15% of the flora has thus far been published, together with the

TABLE 3. Collecting density (specimens/km^2) of Malesia (from *Flora Malesiana*, Ser. 1, 8(1): 3. 1974.).

	Surface (km^2)	Collected to 1950	Collected to 1972	Density Index 1950	Density Index 1972
1. Sumatra	479,513	87,900	99,000	18	21
2. Malay Peninsula	132,604	191,055	232,000	145	175
3. Java	132,474	247,522	260,500	187	197
4. Lesser Sunda Is.	98,625	24,545	36,000	25	36
5. Borneo	739,175	91,550	194,200	12	26
6. Philippine Is.	290,235	180,090	200,000	62	69
7. Celebes	182,870	32,530	34,000	18	19
8. Moluccas	63,575	27,525	30,400	43	48
9. New Guinea	894,855	106,775	233,000	12	26
Totals	3,013,926	989,492	1,319,100	$\bar{x} = 33$	$\bar{x} = 44$

figures for *Flora Neotropica* given below, shows the magnitude of the task in tropical areas and the shortage of botanists to work up the results of inventory. The slow production of monographs is a serious problem and lags behind the progress of development. However, a basic collecting inventory is more important before forests are destroyed. For Pteridophytes, *Flora Malesiana* has published 5 families, 14 genera, and 350 species or 14% of the estimated 2,500 species.

A comparison of the three major continental areas of the tropics in terms of statistics of species descriptions is not as straightforward as it may seem since the different status of knowledge in each flora has tended to result in a rather different species concept in each area. Although the tendency is toward much new synonymy in all three areas, the Malesian botanists seem to have a more conservative attitude to the species concept. For example, Leenhouts (1967) reduced all 255 species of *Allophylus* (Sapindaceae) to the single species *A. cobbe* (L.) Raeusch. Whitmore (1976) cites other examples. The concept of the reticulately polymorphic ochlospecies came from work on the African flora (White, 1962). The species concept in Africa lies somewhere between that of Malesia and the narrower concept that has predominated in the neotropics until recently. It is not the purpose of this paper to evaluate the merits of these different concepts, but an acknowledgement of their existence is necessary for a comparison of data between the different areas. Whitmore (1976) also pointed out the different kinds of species that exist in the tropics, accepting three kinds; the discrete, isolated and morphologically invariable species, the species with distinct infraspecific taxa, and the reticulately variable ochlospecies.

There are numerous local floristic works within the *Flora Malesiana* region, the best known of which is Backer & Bakhuizen van den Brink's (1963–1968) *Flora of Java*.

In the Asian tropics outside Malesia the situation is similar with a reasonable basic inventory but still some neglected areas.

India and Burma have had much less collecting since World War II, but a botanical survey of India is making good progress. In India there is a general reluctance to collect trees in primary vegetation and little specialist collecting

TABLE 4. Collecting status of some Pacific Islands: (1) only casual collecting; (2) poorly collected (not professionally collected); (3) moderately well collected; (4) rather well collected but some gaps; (5) quite well collected. More than one number means different islands in groups collected to different degrees. (Data from F. R. Fosberg, pers. comm.)

Island	Collecting Status		
Revillagigedo	3	Cook Islands	2, 3, 4
Cocos	2	Northern Cook Islands	3, 4
Galápagos	4	Wake Island	5
Easter Island	4	Marshall Islands, Northern	4, 5
Hawaiian Islands	4	Marshall Islands, Southern	3, 4
Phoenix Islands	5	Gilbert Islands	2, 3, 4
Other Central Pacific atolls	4	Naura and Banaba	1
Marquesas	3	Ellice Islands	2, 3
Society Islands (high)	2, 3	Niue Island	4
Society atolls	2, 3, 5	Rotuma Island	4
Tuamoto Islands	2, 3, 4	Wallis and Horne Islands	2
Makatea	2	Tokelau Island	3
Austral Islands	3, 4	Samoa Islands	4
Rapa	3	Tonga Islands	2, 3, 4

has been done. Some local floras are replacing Hooker's (1872–1897) *Flora of India*, as for example the recent *Flora of the Hassan District* by Saldanha & Nicolson (1976). Burma has had the smallest portion of its flora collected.

Thailand has had intensified general collecting since 1960 with a wide coverage of habitats and areas but little specialist collection. Collection has been stimulated by the joint Thai-Danish project on the *Flora of Thailand* under the leadership of Kai Larsen and Tem Smitinand and their collaborators.

Sri Lanka has been extremely well collected and worked up under the *Flora of Ceylon* project directed by F. Raymond Fosberg. This project has included much specialist collecting and the results of this are obvious in the resultant monographs.

Indo-China has had little collection since World War II except for a few vegetational studies in Laos and South Viet Nam. The political upheaval in that region has not been conducive to botanical inventory. The use of chemical defoliants in the war has truly devastated large areas of the forests of Indo-China.

The *Flora Malesiana Bulletin* serves a very fine role of reporting on progress in tropical Asian botany, even in countries outside the range of the *Flora* itself, and is commendable for the amount of useful information generated. The annual columns on progress in Malesian botany, expeditions and exploration, and on recent publications serve to keep us up to date on the state of Asian botany. There is a need for such a bulletin attached to *Flora Neotropica*.

For the tropical Pacific islands Dr. F. R. Fosberg has provided me with the data presented in Table 4. It shows that there are islands which remain poorly collected. Exact statistics on collecting are not available, but there is obviously much still to be done in this area that is so fascinating from the point of view of island biogeography. Dr. A. C. Smith has worked extensively in Fiji so that the archipelago can now be considered well collected, and he is following up with a flora of the islands.

THE NEOTROPICS

The New World tropics are certainly much less known than Africa or Asia and are still in the process of the first basic inventory. New species are still being collected in large numbers from many places, as, for example, the large number of new species from recent collections in the uplands of Panama, from coastal Ecuador, from the forests of the state of Bahia, Brazil, and from many other localities.

The collecting density throughout the neotropics is much less than for Malesia, but added to this, the greater number of species in the neotropical flora and the unevenness of collection throughout the area mean that the basic comprehensive species inventory is still most inadequate and by no means nearing its completion.

Unfortunately there is no equivalent of the *Flora Malesiana Bulletin* or the AETFAT publications in the neotropics. Thus, calculations of botanical activity are harder to make and are less accurate. We hope, however, that the Organization for Flora Neotropica will gradually begin to fill in this information gap as it begins to diversify its interest from only producing taxonomc monographs.

A comparison of many aspects of the ecosystems of Africa and South America is given in Meggers et al. (1973), but it does not cover the subject of inventory in any detail.

The last comprehensive review of the state of neotropical botany was that of Verdhoorn (1945). Much collecting has taken place since 1945 and some aspects, particularly from the conservation point of view, were surveyed in Prance & Elias (1977). In Prance (in press) I give a country-by-country review of the status of botanical exploration in South America, and Gentry (1978a) reviewed the floristic needs of Central America and the Pacific coastal region of northern South America. There is no space to give such a detailed review here, but a few examples will serve to show the situation in the neotropics.

Figure 2 is a distribution map of the pantropical genus *Parinari* in Africa from White (1976). The dots on the map represent presence in a degree square. Figure 3 is a similar distribution map of the same genus in the neotropics. The genus is common and widespread on both continents. It can be seen how much more densely the map of Africa is covered. Judging by the frequency of the individuals I have encountered in fieldwork in the neotropics and by the number of habitats occupied by the different species, I would predict that to be accurate the neotropical map should be almost as densely covered with dots for each degree square as is Africa, and that the distribution difference is actually the result of inadequate collections in South America.

Gentry (1978b) reported on an expedition to Cerro Tacarcuna, a previously unexplored mountain on the Panama-Colombia border. At least 20% of the 239 species collected above 1,400 m have turned out to be new. A similar figure is

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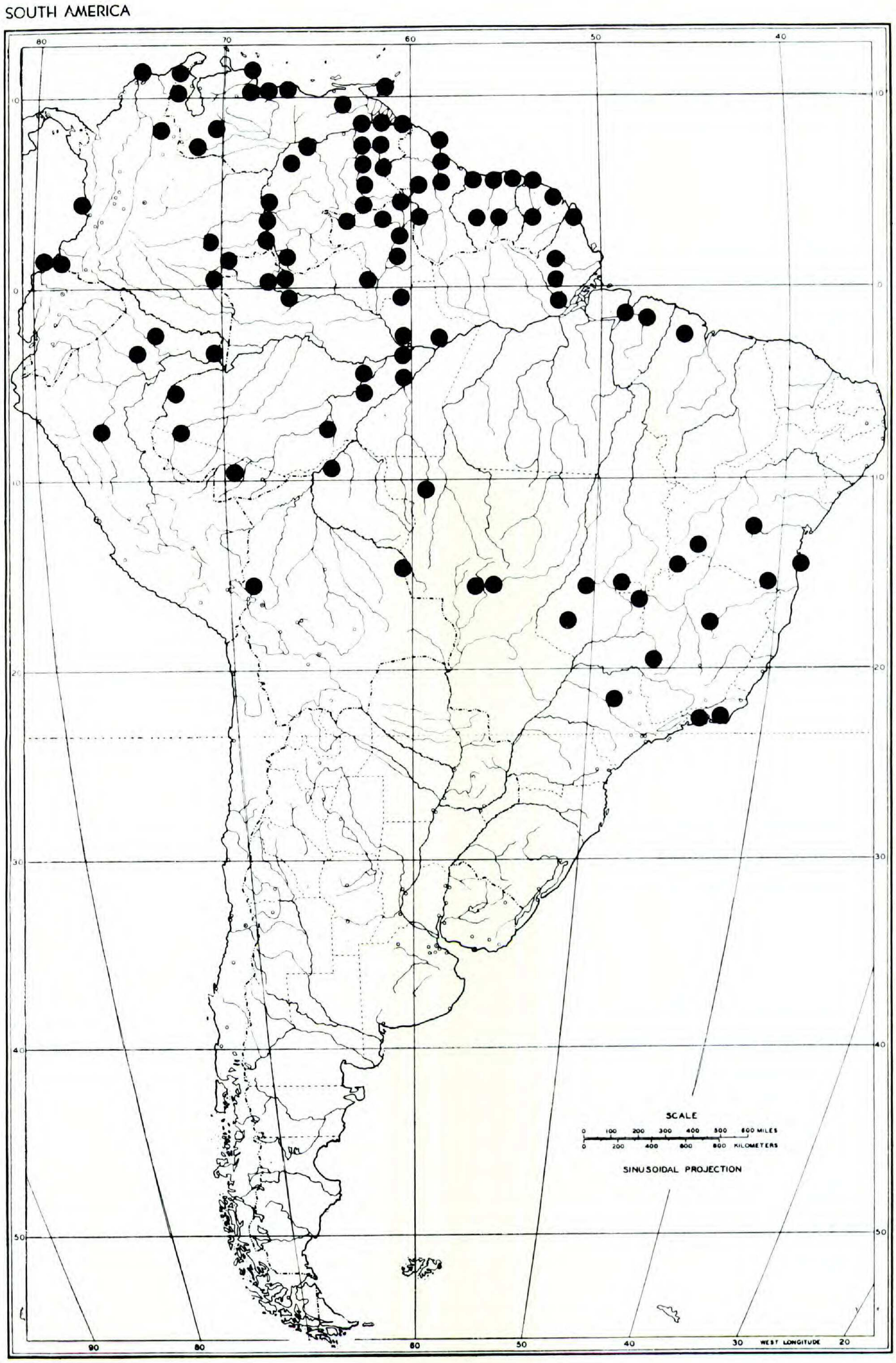
FIGURE 3. Distribution of the genus *Parinari* Aubl. (Chrysobalanaceae) in South America. The dots represent presence in a degree square similar to the African distribution map system used in Fig. 2.



CHRYSOBALANACEAE

18. - Parinari Aubl. (1775)
Synthesis of plates 1-17

TABLE 5. New species and subspecies of Chrysobalanaceae described since the monograph of the family in 1972 (Prance, 1972a).

Species	Locality	Date of collection of the type
Couepia dolichopoda	Peru—Loreto	1972
Couepia edulis	Brazil—Amazonas	1971
Couepia glabra	Brazil—Amazonas	1971
Couepia marlenei	Brazil—Amazonas	1972
Hirtella arenosa	Brazil—Amazonas	1968
Hirtella conduplicata	Brazil—Amazonas	1973
Licania aracaensis	Brazil—Amazonas	1975
Licania chiriquiensis	Panama	1975
Licania furfuracea	Venezuela—Bolívar	1975
Licania jefensis	Panama	1969
Licania jimenezii	Surinam	1971
Licania marlenei	Brazil—Amazonas	1972
Licania montana	Venezuela—Lara	1975
Licania morii	Panama	1975
Licania octandra (Hoffmgg. ex R. & S.) Kuntze subsp. *grandifolia*	Brazil—Amazonas	1973
Licania pakaraimensis	Venezuela—Bolívar	1973
Licania stewardii	Brazil—Amazonas	1974
Licania cecidiophora	Peru—Loreto	1974
Licania sp. nov. 1	Ecuador	1969
Licania sp. nov. 2	Panama	1975
Licania sp. nov. 3	Brazil—Amazonas	1976
Licania sp. nov. 4	Colombia—Valle	1972
Licania sp. nov. 5	Panama	1972
Hirtella sp. nov. 1	Peru—Loreto	1976
Hirtella sp. nov. 2	Brazil—Amazonas	1976

true of a recent collection of J. Murça Pires in Amazonas, Brazil, from the recently discovered and isolated sandstone peak Serra Acará. The number of new species that are still being described from recent collections is indicative of the state of collecting. In 1972 I monographed the neotropical Chrysobalanaceae (Prance, 1972a). The monograph recognized 328 species in the 8 genera. Table 5 lists the 26 new species that I have described (or are ready to be described) in the five years since I completed the monograph. The new species amount to 7.93% of the original number of species. All except three of the new species are based on type collections made since 1970. Many other monographic, floristic, and descriptive works on the neotropical flora, especially from Panama southward, are adding species at a similar rate. The number of new species in Table 5 from the forests of Panama and from Amazonia points to two of the under-collected areas of the neotropics, although there are also many other places outside the main distribution range of the Chrysobalanaceae. In addition to these new species, large range extensions of several of the original 328 species have occurred. For example, *Licania affinis* Fritsch was reported as a species confined to the Guianas. It has recently been collected several times in Panama, adding another species to the increasing list of Guiana-Panama disjunctions reported in Gentry (1975). While this is a true disjunction, many other species previously thought to be of local distribution are now seen to have much wider continuous distributions. For example, in Prance (1972a) I cited *Couepia longipendula* Pilger as endemic to the Manaus region of Amazonia. In 1973 I collected it over 1,200 km away on the Rio Curicuriari. It was then collected later in 1973 on the Rio Cunhua also over 1,000 km from Manaus to the southwest rather than northwest, showing that this species is actually quite widespread in Amazonia (Fig. 5).

Gentry (1978b) described a similar case in a species of *Siparuna* known only from Panama and western Ecuador, 1,500 km apart, but subsequently collected in Chocó in Colombia.

The number of species added to the Chrysobalanaceae and other groups in recent neotropical monographs is in marked contrast to the situation in African and Asian Chrysobalanaceae where few new species are being discovered. Jacobs (1974) cites a good example from the Malesian families monographed by Dr. P. W. Leenhouts (see also Leenhouts, 1976). The following additions to *Flora Malesiana* monographs have been made:

Burseraceae (108 species), additions after 14 years: 1;
Connaraceae (38 species), additions after 12 years: 0;
Dichapetalaceae (15 species), additions after 13 years: 0;
Goodeniaceae (8 species), additions after 13 years: 3.

The neotropics, as reflected in *Flora Neotropica* has a much less complete species inventory. In 1972 I monographed neotropical Dichapetalaceae (41 species; Prance, 1972b), since that date I have described 3 new species showing the same trend as for neotropical Chrysobalanaceae. However, this comparison of species between Malesia and the neotropics is further complicated by the differences in species concepts referred to earlier.

Although many new species are being added to the neotropical flora, also much synonymy is taking place. For example, in the monograph of Chrysobalanaceae (Prance, 1972a), where 75 new species were described, 76 names were placed in synonymy, giving an almost even result. Monographic treatments are finding many "regional" species. I suspect that in Lecythidaceae, which I am currently monographing with Dr. Scott Mori, the percentage of synonymy will be even higher since the last monograph by Reinhardt Knuth (1939). Knuth was a renowned splitter, and did not rectify the species described from several different regions under different names.

The dangers of such an incomplete inventory are obvious. Extreme caution must be taken with drawing biogeographic conclusions from plant distributions as we know them today. Some disjunctions are now well established and have logical historic bases, such as the climatic changes in the Pleistocene and post-Pleistocene (Haffer, 1969; Prance, 1973; Toledo, 1976); others are artifacts of a poor collection sample. Such disjunction as Panama-Guiana or Amazonia to the coastal forests of Bahia are well established. Lamentably, the destruction of the forest is proceeding at such a rate that we may never be able to put together the accurate distribution pattern of many neotropical plants.

Central America is one of the better known regions of the neotropics with

FIGURE 4. The distribution and range extension pattern of *Couepia longipendula* Pilger.

TABLE 6. Collecting density in Central America, data from Gentry (1978a) and other sources.

Country	No. of Species	No. of Collections	Surface Area (km^2)	Density Index (km^2)
Guatemala	8,000	80,000	108,880	0.73
Belize	3,000	25,000	22,272	1.12
El Salvador	2,500	8,000	21,392	0.37
Honduras	5,000	40,000	112,079	0.36
Nicaragua	5,000	5,000	129,990	0.038
Costa Rica	8,000	70,000	50,695	1.38
Panama	8,000	100,000	75,643	1.32

regional floras existing or in preparation in most countries. Work on the regional floras such as Guatemala, Costa Rica, and Panama has stimulated much botanical collection. Table 6 gives the approximate collecting density for the region. Only in two countries does it reach as high as 1.3 specimens per square kilometer. This may be compared to Table 3 where the lowest density for Malesia is Celebes with 19 specimens per square kilometer. Such a table for South America would be even lower than that of Central America. Holdridge (1976) discussed the reasons for the diversity of the Central American vegetation.

Perhaps the richest rain forest in the neotropics is that of Chocó, Colombia where annual rainfall is up to 10,000 mm (Lellinger & de la Sota, 1972). Only about 8,000 collections have been made from this area, first by Cuatrecasas and more recently by Gentry and Forero. It is certainly one of the most important and most interesting areas in the tropics for future collection. Colombia as a whole has the richest flora in South America with perhaps half the species of the neotropical flora occurring within her territory, 45,000 species (50,000 according to Schultes, 1951). Colombia as a country is still poorly collected and many areas rich in endemism such as Sierra de la Macarena and Sierra Nevada de Santa Marta are poorly known botanically.

Venezuela is relatively well explored botanically in comparison to many other countries of South America, yet Steyermark (1974) stated that "less than 2% of Venezuela has been explored botanically." Maguire (1970) estimated that more than 75% of the flora of the Guyana highlands is endemic. With the high endemism from mountain top to mountain top in that region, even the intensive expeditions of Maguire, Steyermark, and other collaborators has just begun to inventory the flora of the sandstone mountain tops. The large state of Apure in Venezuela offers diverse habitats, savannas, lakes, rivers and rain forests, rarely visited by botanists.

In the Guianas, French Guiana remains the least explored and is in need of much more intensive fieldwork.

Svenson (1945) stated that "Ecuador is botanically one of the least known, though one of the richest countries in South America." This is still true today, although the Swedish-based *Flora of Ecuador* project has stimulated much more collecting activity in recent years. This has concentrated on the highland areas, leaving the Amazonian part of Ecuador still very poorly known.

Peru also offers a wide range of plant habitats, from arid desert regions to the humid tropical forest of her Amazonian territory. Despite the long history of collection in Peru, it is still poorly known botanically. The *Flora of Peru* initiated by Macbride in 1936 has recently been reactivated as a cooperative Field Museum-Missouri Botanical Garden project. This has stimulated more collections in recent years, particularly from the poorly collected Amazonian region.

Brazil, the largest country in South America, has a long history of botany, and a great diversity of vegetation. With an area of 8,511,965 km^2, the collecting density of the country is certainly well under 1 specimen per square kilometer. National herbaria have about 2 million specimens. Some of the poorly collected areas of Brazil include the state of Acre, Serra Pacaás Novas in Rondônia, the forests of northern Mato Grosso and Serra Cachimbo in Amazonia. Besides the Amazonian region there are many other neglected areas of Brazil such as the coastal forest of Bahia and Espiríto Santo and some parts of the arid caatinga region.

In January 1976 Brazil initiated an ambitious program called *Programa Flora.* This program plans to make a detailed inventory of Brazil's vegetation by collecting programs and by the preparation of a computerized label data bank of Brazilian herbaria. The program is divided into five regional projects and *Projeto Flora Amazônica* has already begun. Arrangements for North American participation in the collecting program have been made and collecting will start in the fall of 1977.

Bolivia is probably the least collected of all South American countries. Little collecting has been carried out since the time of the summary of collections from Bolivia by Herzog (1923: 1–4). The lack of a strong national botanical work in Bolivia has also hampered fieldwork by foreigners. There is a great need for collections from all over Bolivia.

Paraguay, which lies geographically half within the tropics, is another poorly collected country where only about 30 collectors have worked extensively. Argentinian botanists have visited Paraguay and made important collections there. There is very little primary vegetation left in Paraguay.

The Caribbean islands of the Antilles have a flora of 12,000–15,000 species (Howard, 1977). The islands, which stretch over 1,700 miles east to west and 1,200 miles north to south, have many local endemics. For example León and Alain estimated that almost 50% of the 6,000 species of Cuba are endemic, and Hispaniola has 33% endemism in its flora of 5,000 species (Alain, pers. comm.). The history of floristic work has been a one-island approach which has led to many species being described from several islands, and more island "endemics" are being reduced than new species described. One of the needs of Caribbean botany is a monographic approach to compare elements of its flora with South and Central America and to calculate the true percentage of endemism. Howard (1977) has noted that "plant life of the Caribbean Islands cannot be regarded as unknown or needing immediate study or a massive collecting program." The area has been well collected in comparison to Latin America.

There is, however, a need for any of the experimental type collections listed in the next section. Howard (1977) lists many examples of environmental de-

TABLE 7. The most recent country or regional floras of Latin America.

Country	Status	Reference
Guatemala	(almost complete)	Standley & Steyermark (1958–)
Belize	Annotated checklist	Standley & Record (1936)
El Salvador	Annotated checklist	Standley & Calderón (1925)
Honduras	Various regional floras and checklists	Standley (1930, 1931)
Nicaragua	Initiating Flora, none published	
Costa Rica	Flora in progress	Burger (1971–)
Panama	Flora nearing completion	Woodson & Schery (1943–)
	Flora of Canal Zone	Standley (1928)
Colombia	Generic Flora initiated, none published	
	Flora of the State of Cundinamarca in progress	Pinto-Escobar (1966–)
Venezuela	Flora in progress	Lasser (1968–)
Guyana	No flora	
Surinam	Flora under revision	Pulle (1932–)
French Guiana	Compiled incomplete Flora, no modern Flora	Lemée (1953)
Ecuador	Flora in Progress (6 families published)	Harling & Sparre (1973–)
Peru	Flora reactivated, in progress	Macbride (1936–)
Brazil	No modern Flora since Martius	Segadas-Vianna (1965–)
	Various local floras e.g. Santa Catarina, Restingas, etc.	Reitz (1965–) Hoehne (1940–)
Bolivia	No Flora	
Paraguay	No Flora	

struction in the Caribbean, and, as elsewhere, further collecting data is needed for conservation information.

Floras exist for many of the larger islands, for example, Cuba (León & Alain, 1946–1969), Puerto Rico (Britton & Wilson, 1923–1930), Jamaica (Adams, 1972; Fawcett & Rendle, 1910–1936), and that of Hispaniola is in preparation by Alain.

In spite of the better collecting status of the region, there are still novelties being found in the Caribbean, for example, Alain recently found a new species of the previously South American genus *Talisia* in Santo Domingo (Alain, pers. comm.). Some of the smaller islands of the lesser Antilles have been overlooked.

Table 7 gives a list of the most important local floras in the neotropics. The collecting for the floras has done much to stimulate the inventory of the region, but most of the floras are based on inadequate specimen samples and consequently new species and extension of ranges must be added to the floras of each country. For example, the earlier family treatments of the *Flora of Panama* (Woodson & Schery 1943) are very inadequate in their species coverage and nomenclature. The recent exploration of the moist forests of Panama has added many elements to the flora. Another result of such an emphasis on regional floras has been the description of many species several times in the various regional floras. Even Paul Standley (1928), known as a "splitter," commented that "in tropical America . . . the flora has been studied from isolated centers with little regard for the species accepted at other centers, but with the assumption that each area is floristically distinct. Correlation through monographic work, covering a group throughout its range, will reduce the species that have been multiplied unnecessarily."

TABLE 8. Number of species described in *Flora Neotropica* monographs.

Volume	Author	Group	No. of Species
A. Flowering Plants			
1	Cowan (1968)	*Swartzia*	127
2	Cuatrecasas (1970)	Brunelliaceae	50
7	Berg (1972)	Olmedieae-Brosimeae	68
8	Maas (1972)	Costoideae	41
9	Prance (1972a)	Chrysobalanaceae	328
10	Prance (1972b)	Dichapetalaceae	39
11	Prance (1972c)	Rhabdodendraceae	3
12	Prance & Silva (1973)	Caryocaraceae	23
13	Rogers & Appan (1973)	*Manihot/Manihotoides*	99
14a	Smith & Downs (1974)	Pitcairnioideae	731
14b	Smith & Downs (1977)	Tillandsioideae	815
15	Morley (1976)	Memecyleae	81
18	Maas (1977)	Zingiberoideae	61
		TOTAL	2,466
B. Fungi			
3	Singer (1970a)	Omphalinae	52
4	Singer (1970b)	Phaeocollybia	4
5	Singer (1970c)	Strobilomycetaceae	13
6	Lowy (1971)	Tremellales	148
16	Farr (1976)	Myxomycetes	280
17	Singer (1976)	Marasmieae	322
		TOTAL	819

Recent monographic work has shown the words of Standley to be true, and most neotropical monographs include a considerable amount of synonymy, but at the same time also include a large number of new species.

Another stimulus to collecting in the neotropics is the *Flora Neotropica* monograph series initiated in 1964. Table 8 gives a list of the monographs published to date: 2,466 species or 2.74% of the estimated total of 90,000 flowering plants have been treated, and 819 species or 1.64% of the 50,000 fungi have been treated. Since the series also includes ferns, bryophytes, and algae, the task to be completed is enormous. Already new collections are outdating the existing treatments, see, for example, Table 5, the Chrysobalanaceae added since 1972. Maas (1977) contains a supplement to Maas (1972) which adds many new data.

THE FUTURE INVENTORY

In summary, Africa is the best collected continent of the tropics and is closely followed by Asia and Malesia. In these areas a basic inventory including most species exists, but the sample size of many species is still inadequate for a true understanding of their biology and ecology. In the neotropics the basic inventory is still underway, and many new species are still being found. There are many areas of South America still to be explored botanically. However, collecting should not now be slowed down anywhere in the tropics. A different emphasis is needed now to provide an adequate experimental sample. Some of the foci for future collecting are outlined below, and these correspond with the needs of a more experimental approach to tropical taxonomy. Although herbarium inventory is still taking place in many areas, the experimental methods can often be carried out at the same time. For example, it is easy for any collector to carry fixatives and collect bud material for the study of chromosome numbers.

Throughout the tropics many species are known from incomplete material. Future collecting should focus on previously inadequately collected material such as the fruits of many tall forest trees, and collections should be accompanied by good field data and notes on dispersal where possible. Jacobs (1976) pointed out that lianas are poorly collected and gave a succinct summary of collecting problems in lianas. The large fleshy, monocotyledons such as Zingiberaceae (see Burtt, 1976), Musaceae, and Araceae are poorly collected, and pickled flowers are essential for adequate study. Much more liquid preserved material should be collected and distributed to specialists. At the outset of my work on Lecythidaceae it was necessary to obtain a large collection of preserved flowers over a period of several years before the complicated androecium structure of the large fleshy flowers could be interpreted. Other groups that are poorly collected include tropical macrophytes, bamboos, palms, and *Utricularia* (see Taylor, 1977, for collecting techniques in *Utricularia*).

Van Steenis (1977) made an important plea to tropical collectors to improve their field data. He pointed to the need for further label data on color, scent, size, texture, structure, and habit of specimens, for liquid material, and for black-and-white photographs of habit and habitat. As studies on floral biology, phytogeography, and evolution in the tropics increase these are needed. It is often better to collect fewer numbers but to document them well.

Economic plants have often been neglected by taxonomist collectors who have the habit of leaving such things to economic botanists, agriculturists, or foresters. This has resulted in inadequate sampling of many of the most important economic plants and even their wild relatives. The contrary has occurred in some tropical areas where the local herbarium is a Forestry Herbarium. Collecting was concentrated on forest trees and "noneconomic" plants like forest herbs and lianas have been neglected, for example, in North Borneo, Surinam, and French Guiana where forest herbaria are the most active botanical institutes.

Plants of secondary vegetation have always been neglected as "inferior cousins" of the primary forest. Some secondary areas have an extremely rich and interesting flora, and they should also be further collected. For example, many of the hard-to-collect forest lianas in Bignoniaceae, Malpighiaceae and Menispermaceae occur abundantly in the secondary forest areas of the neotropics. A survey by Rodrigues (unpublished data) found 374 species in 63 families on an area of 3,500 m^2 of secondary forest near Manaus.

Various authors have drawn attention to the importance of secondary forest in conservation of primary areas. Thus, use of secondary areas for plantations can often relieve pressure on primary areas (Budowski, 1977). Secondary forest also played an important role in the evolution of the tropical flora (Gómez-Pompa, 1972). It is, therefore, most important that we make a better inventory of secondary areas in the tropics.

General collecting is important and has really provided the basic inventory of the tropical vegetation. However, a specialist in any family finds far more interesting things about his group than the general collector. The specialist soon learns to recognize his group from the diversity of the forest, and field studies by specialists have contributed many of the interesting results from the tropical forest. I have been accompanied by many specialists on my botanical expeditions and have often been impressed at their ability to find their groups, and the representation of any family in our collections always increases when there is a specialist present. There is much in favor of taxonomic focusing in collection. A general collector who concentrates on certain groups will also produce interesting collections.

Another important aspect for tropical forest areas is the concentration on a small area over an extended period. This is best done by resident botanists and can be highly rewarding, from both a taxonomic and ecological point of view. For example the selection of one hectare of forest for study in a relatively well-known area near Manaus, Brazil yielded many interesting results, including at least two new species from the 236 tree species on the hectare (Prance et al., 1976).

The detailed botanical study of Barro Colorado Island in Panama (Croat, in press), was based on much fieldwork and treats 1,400 species from an area of 14.8 km^2. This study has also enhanced many other interdisciplinary studies and is a good example of the usefulness and importance of minifloras and treatments and inventories of small areas of the tropical forest. An area where the individual trees have been identified soon becomes the focus of many other studies apart from the original botanical inventory. Often the biggest problem facing other tropical biologists is the lack of such well-inventoried areas for their research. When we had inventoried the hectare of forest near Manaus, we were soon followed by entomologists, soil zoologists, and mycorrhiza specialists who could link their work to an accurate botanical inventory. Too many detailed tropical forest inventories in the past were carried out by foresters who relied on local names and did not collect enough herbarium specimens to document their inventories. There is a need for further well-documented inventories of small areas from throughout tropical forests. This type of inventory is quite as important as general collecting and often yields data of great use for conservation, as well as ecology and other disciplines. It is one of the best ways to encourage interdisciplinary research. Much of the interesting work that has come from the Organization for Tropical Studies in Costa Rica is the result of concentration on small, well-inventoried areas of forest.

Inventory must not be isolated from the other subjects under discussion in this symposium. It is significant that other speakers are covering animal-plant interactions, tropical ecosystems, and integrative approaches to the study of plant structure. Future collectors need to be more aware of the research being carried on in these and other fields, and to be ready to contribute data. The lack of pollinator data in the tropics is enormous, and both the general collector and the specialist collector can contribute much to pollination ecology by making a few observations on flower visitors, scent, etc.

Inventory in the tropics does not just include the collection of herbarium specimens which I have emphasized in this paper. It includes inventory of pollination mechanisms, other insect-plant relationships, phenology, mycorrhiza, types of photosynthesis, nitrogen fixing bacteria, chromosome numbers and morphology (Raven, 1975), self-incompatibility mechanisms (Bawa, 1974; Bawa & Opler, 1975), hybridization—of which we know virtually nothing in the tropics (Raven, 1976c), and many other aspects which are summed up by Farnworth & Golley (1974). Let us remember the words of Merxmüller (1970) in reference to biosystematic work in the tropics, "A conservative today who would work on insufficient materials only, would soon be a laughingstock," and try to improve the situation rapidly.

One of the most striking facts about the tropics is that the vast majority of specimens are deposited in herbaria in temperate regions. The history of settlement and development has dictated the distribution of specimens, and this is now a major problem for the development of systematics and conservation in the tropics. There are very few major herbaria anywhere in the tropics, and they can easily be enumerated on two hands. They include Bogor and Singapore in Malesia; Calcutta in India; The East African Herbarium in Nairobi; The Forest Herbarium in Ibadan, Nigeria; and the Jardim Botânico and Museu Nacional in Rio de Janeiro. There are of course fortunately a large number of smaller tropical herbaria that play an important local role; for example, there are at least 49 herbaria in Brazil alone, 16 in Colombia, etc. (see Table 9). Their work is hampered by the lack of type specimens and literature. Not only are the specimens deposited in Europe and North America, but also the best literature about an area is often in a foreign language such as English or German.

This lack of resources has also been accompanied by a lack of trained personnel in tropical countries which has also hampered the progress of inventory. These facts, coupled with the increase of nationalism, have led to the implementation of strict rules to govern collecting activity by foreigners with the result that there are some tropical areas where it is impossible for foreigners to collect at present.

In order to complete the inventory of the tropics it is necessary to stimulate more training of local resident botanists (Prance, 1975), to deposit properly identified material in all tropical herbaria equipped to house them, and to publish in local journals in the countries where we are working. This will not only have an effect on the standard of botany in those countries but also contribute significantly to conservation. The enthusiasm and concern for conservation displayed by botany and ecology students in our training program in Manaus, Brazil, is an unforgettable experience. These young biologists will be a powerful force for conservation in a few years' time. The issue of conservation is even more sensitive than collecting, and it cannot be accomplished by foreigners without much support from within the host country.

In order to progress in the future inventory and conservation of the plant resources of the tropics, botanists must adhere more strictly to the excellent guidelines agreed upon by many major United States Research Institutions (Hairston, 1970).

TABLE 9. A summary of South American herbaria and areas covered.

Country	Number of Herbaria	Total No. of Herbarium Specimens	Area of Country (km^2)
Colombia	16	260,000	1,138,914
Venezuela	5	190,000	912,050
Guyana	2	30,000	214,969
Surinam	1	16,000	163,265
French Guiana	1	13,500	91,000
Ecuador	4	7,500	283,561
Peru	6	275,000	1,285,216
Brazil	49	2,000,000	8,511,965
Bolivia	1	1,000	1,098,581
Paraguay	1	1,000	406,752
Uruguay	3	115,000	177,508
Chile	4	160,000	756,945
Argentina	22	3,000,000	2,776,889
TOTALS	115	6,068,500	17,817,615
U.S.A. (1974)	1,127	45,811,608	9,360,882

Inventory of the tropics is not nearly complete, yet destruction of their natural ecosystems continues not only unabated, but at a faster rate than inventory. There is an urgent need to accelerate the process of inventory and at the same time to encourage alternatives that will buy time for us by delaying the destruction of the world's richest biome. The more knowledge we gather about the ecosystem the better the possibility that we can use it on a sustained-yield basis. In the meantime we should do all we can to encourage some of the alternatives: the exploitation of seasonal forests (Budowski, 1976; Goodland & Irwin, 1977), floodplain forests (Goodland & Irwin, 1975; Prance, in press), of secondary forest (Budowski, 1975; Farnworth & Golley, 1974), and better distribution of food produced in temperate regions. Clearly there is still an enormous challenge ahead of us in the task of a complete tropical inventory.

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